

WE CLAIM:

1. A transparent glass-ceramic containing a predominant crystal phase of forsterite, the glass-ceramic having a composition, in weight percent on an oxide basis, consisting essentially of about:

40-60% SiO_2 ;

10-25% Al_2O_3 ;

18-30% MgO ;

3-10% Na_2O ;

0-10% K_2O ;

>5-15% TiO_2 ; and

said glass-ceramic has a crystallinity of at least about 30% by weight of forsterite components at a liquidus temperature of about 1525°C or below.

2. The glass-ceramic according to claim 1, wherein Na_2O and K_2O are both present in about a 1:1 molar ratio.

3. The glass-ceramic according to claim 1, wherein said TiO_2 content by weight in said composition is greater than about 6%, and less than about 9%.

4. The glass-ceramic according to claim 1, wherein said composition further includes, in weight percent on an oxide basis, up to about 1.3% chromium oxide.

5. The glass-ceramic according to claim 4, wherein said composition includes, in weight percent on an oxide basis, about 0.05% to about 0.75% chromium oxide.

6. The glass-ceramic according to claim 1, wherein said composition further includes, in weight percent on an oxide basis, up to about 20% GeO_2 .

7. The glass-ceramic according to claim 1, wherein said composition includes a transition metal ion selected from the group consisting of Ni^{2+} , V^{3+} , Co^{2+} , Cr^{4+} , Cu^{2+} , Cu^{1+} , Mn^{2+} , Fe^{2+} , and Ti^{3+} .
8. The glass-ceramic according to claim 1, wherein said crystallinity is about 35% or more by weight of forsterite components.
9. The glass-ceramic according to claim 1, wherein crystals in the crystal phase have a size no larger than about 60 nm.
10. The glass-ceramic according to claim 1, wherein crystals in the crystal phase have a size between about 10 nm to about 35 nm.
11. A transparent glass-ceramic with a crystallinity of at least about 30% by weight of forsterite components at a liquidus temperature of about 1525°C or below, having a composition, in weight percent on an oxide basis, consisting essentially of about:
 - 43-55% SiO_2 ;
 - 11-16% Al_2O_3 ;
 - 20-26% MgO ;
 - 3.5-6.5% Na_2O ;
 - 3.0-8.0% K_2O ;
 - 5.5-9.0% TiO_2 .
12. The glass-ceramic according to claim 11, wherein Na_2O and K_2O are both present in about a 1:1 molar ratio.
13. The glass-ceramic according to claim 11, wherein said TiO_2 content by weight in said composition is greater than about 6%, and less than about 9%.
14. The glass-ceramic according to claim 11, wherein said composition further includes, in weight percent on an oxide basis, up to about 1.3% chromium oxide.

15. The glass-ceramic according to claim 14, wherein said composition includes, in weight percent on an oxide basis, about 0.05% to about 0.7% chromium oxide.
16. The glass-ceramic according to claim 11, wherein said composition further includes, in weight percent on an oxide basis, up to about 20% GeO_2 .
17. The glass-ceramic according to claim 11, wherein said composition includes a transition metal ion selected from the group consisting of Ni^{2+} , V^{3+} , Co^{2+} , Cu^{2+} , Cu^{1+} , Mn^{2+} , Fe^{2+} , and Ti^{3+} .
18. The glass-ceramic according to claim 11, wherein said crystallinity is about 35% or more by weight of forsterite components.
19. The glass-ceramic according to claim 11, wherein crystals in the crystal phase have a size no larger than about 60 nm.
20. The glass-ceramic according to claim 11, wherein crystals in the crystal phase have a size between about 10 nm to about 35 nm.
21. A method of dissolving at least 30 % by weight of forsterite component in a glass-ceramic, the method comprising:
 - providing a $\text{R}_2\text{O-MgO-Al}_2\text{O}_3\text{-SiO}_2$ glass composition, wherein R is an alkali ion, containing, in weight percent, at least about 3% of Na_2O coupled with greater than 5% of TiO_2 ;
 - melting said glass at a temperature between about 1575°C to about 1650°C.
22. The method according to claim 21, wherein said glass has a composition, in weight percent on an oxide basis, consisting essentially of about: 40-60% SiO_2 ; 10-25% Al_2O_3 ; 18-30% MgO ; 3-10% Na_2O ; 0-10% K_2O ; >5-15% TiO_2 .

23. The method according to claim 21, further comprising achieving at least 30 % by weight of forsterite component in said glass-ceramic at a liquidus temperature of about 1525°C or below.
24. The method according to claim 22, wherein Na₂O and K₂O are both present in about a 1:1 molar ratio.
25. The method according to claim 22, wherein said TiO₂ content by weight in said composition is greater than about 6%, and less than about 9%.
26. The method according to claim 22, wherein said composition further includes, in weight percent on an oxide basis, up to about 1.3% chromium oxide.
27. The method according to claim 26, wherein said composition includes, in weight percent on an oxide basis, about 0.05% to about 0.7% chromium oxide.
28. The method according to claim 22, wherein said composition further includes, in weight percent on an oxide basis, up to about 20% GeO₂.
29. The method according to claim 22, wherein said composition includes a transition metal ion selected from the group consisting of Ni²⁺, V³⁺, Co²⁺, Cr⁴⁺, Cu²⁺, Cu¹⁺, Mn²⁺, Fe²⁺, and Ti³⁺.
30. The method according to claim 22, wherein said crystallinity is about 35% or more by weight of forsterite components.
31. The method according to claim 22, wherein crystals in the crystal phase have a size no larger than about 60 nm.
32. The method according to claim 22, wherein crystals in the crystal phase have a size between about 10 nm to about 35 nm.

33. An optical element selected from the group consisting of an optical fiber, a gain-medium, a laser, and an amplifier, said element comprising: a transparent glass-ceramic containing a crystallinity of at least about 30% by weight of forsterite component at a liquidus temperature of about $\leq 1525^{\circ}\text{C} \pm 5^{\circ}\text{C}$ or below, the glass-ceramic having a composition, in weight percent on an oxide basis, consisting essentially of about: 40-60% SiO_2 ; 10-25% Al_2O_3 ; 18-30% MgO ; 3-10% Na_2O ; 0-10% K_2O ; and >5-15% TiO_2 .
34. The optical element according to claim 33, wherein Na_2O and K_2O are both present in about a 1:1 molar ratio.
35. The optical element according to claim 33, wherein said TiO_2 content by weight in said composition is greater than about 6%, and less than about 9%.
36. The optical element according to claim 33, wherein said composition further includes, in weight percent on an oxide basis, up to about 1.3% chromium oxide.
37. The optical element according to claim 36, wherein said composition includes, in weight percent on an oxide basis, about 0.05% to about 0.7% chromium oxide.
38. The optical element according to claim 33, wherein said composition further includes, in weight percent on an oxide basis, up to about 20% GeO_2 .
39. The optical element according to claim 33, wherein said composition includes a transition metal ion selected from the group consisting of Ni^{2+} , V^{3+} , Co^{2+} , Cr^{4+} , Cu^{2+} , Cu^{1+} , Mn^{2+} , Fe^{2+} , and Ti^{3+} .
40. The optical element according to claim 33, wherein said crystallinity is about 35% or more by weight of forsterite components.
41. The optical element according to claim 33, wherein crystals in the crystal phase have a size no larger than about 50 nm.

42. The optical element according to claim 33, wherein crystals in the crystal phase have a size between about 10 nm to about 35 nm.